Modeling pesticides emissions for Grapevine LCA: adaptation of Pest-LCI model to viticulture

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Modeling pesticide emissions for Grapevine Life Cycle Assessment: adaptation of PestLCI model to viticulture

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Context and objectives

Area under vines (2012) :

7.5Mha 3Mha

Vine very sensitive to pests and diseases…

High pesticides active ingredients (PAI) consumption

Need to address the lack of viticulture specific pesticide emission LCI model,

We propose

A PestLCI 2.0 version tailored to appropriately account for viticulture specificities

USETox™ specific characterization factors

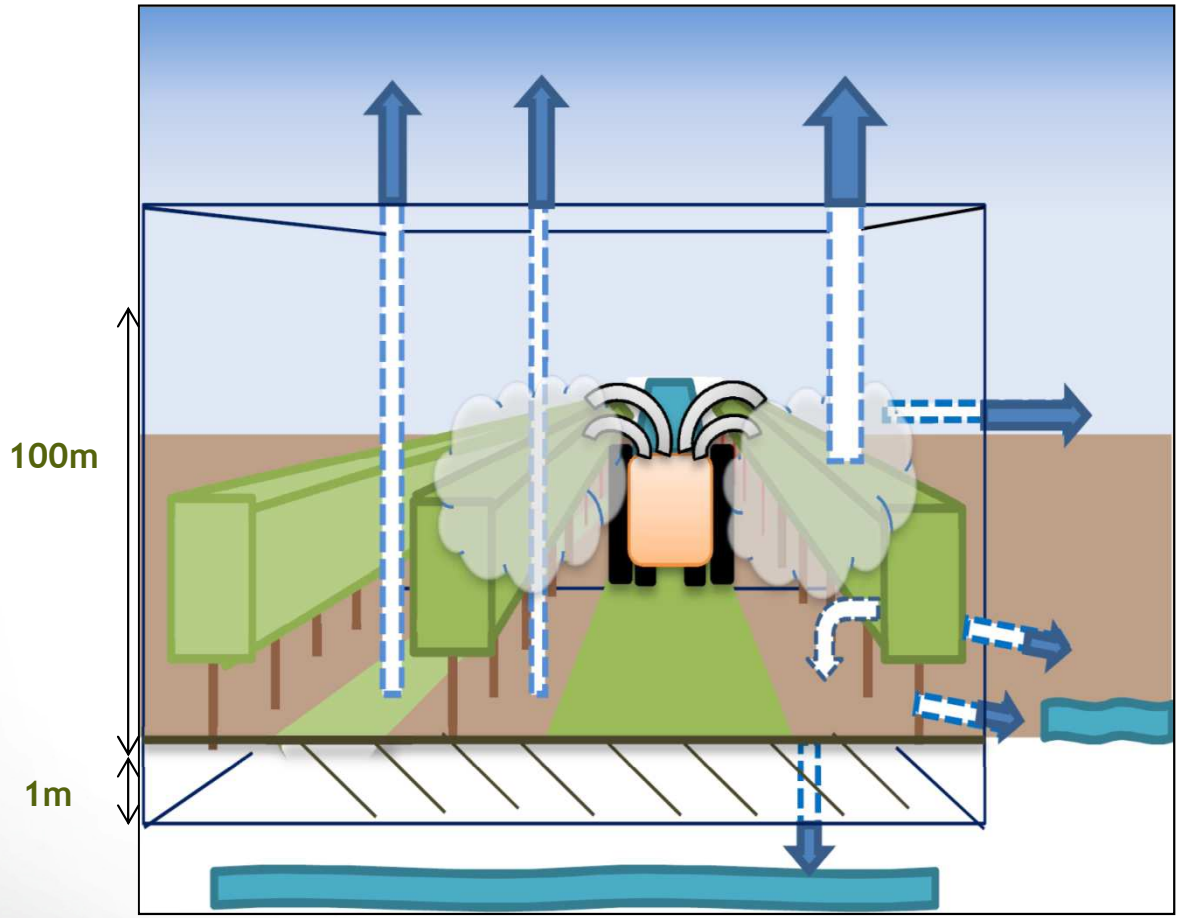
PestLCI 2.0/USETox™ combination on 2 cases

Comparison to 2 static approaches

Method: Pest-LCI 2.0 model

PestLCI - calculates the primary distribution of p.a.i.s between air, crop and soil
- estimates p.a.i.s. fate to air, surface water, groundwater

(Birkved et al. 2006, Dijkman et al. 2012)



Method: Addressing specificities of viticulture

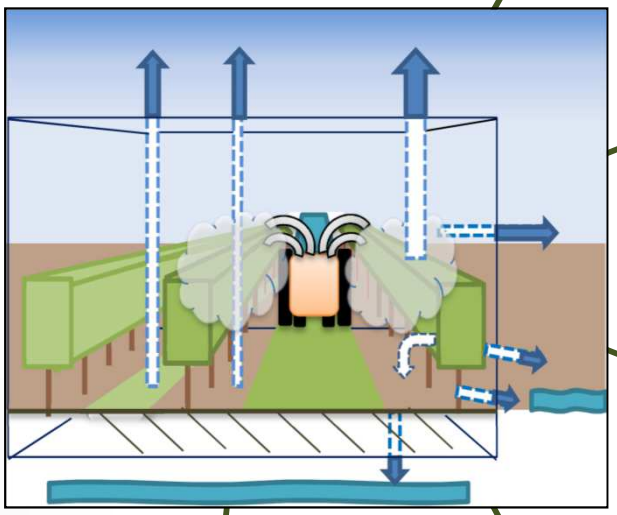
9 Specific sprayers

- **Vertical canopy**
- **Different spraying modes**

I distrib.

Double cropping system

- **Presence of cover crop**
- **under the vine**



29 Specific a.i.s.

- **numerous pest and diseases**

II distrib.

18 FwEtox CF in USETox™

Site specific conditions

- **5 Soils**
- **22 Climatic datasets**

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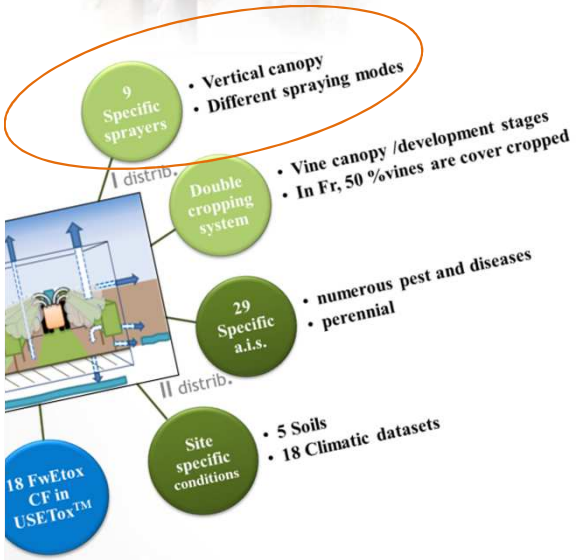
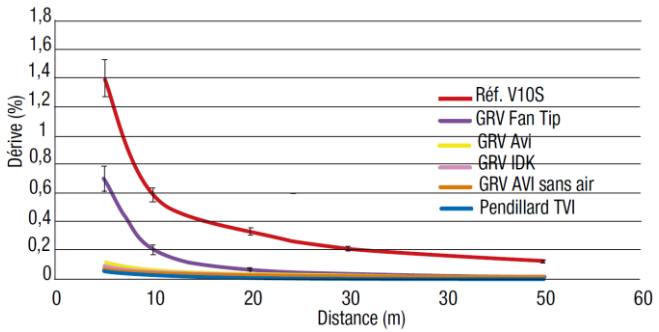
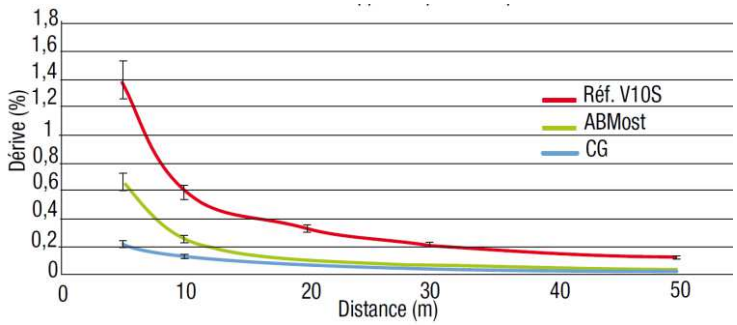
Method
I distribution : drift, specific sprayers



Sprayers: drift curves introduced in PestLCI from Codis et al. 2011





Codis et al. 2011

Plus Tunnel sprayer (Ganzelmeier 2000)

Picture Codis et al 2011

Picture Dagnaud

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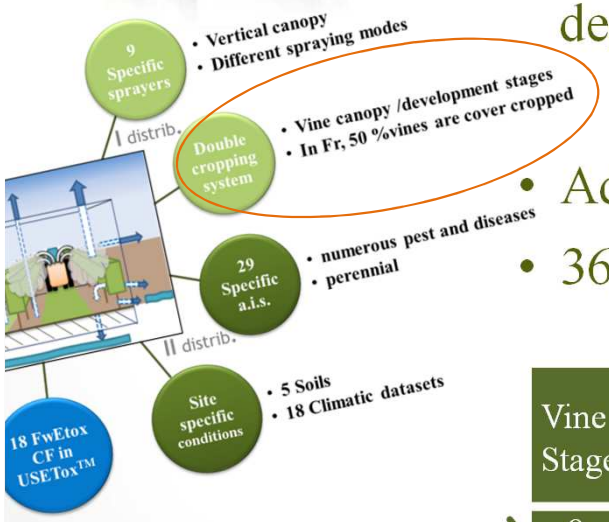
Method : I distribution, double cropping system



- Primary distribution process in PestLCI : wind drift (f_d), pesticide deposition on soil (f_s) pesticide deposition on leaves (f_l)

$$f_d + f_s + f_l = 1$$

- Addition of cover crop interception : $f_l = f_{vine} + (f_{covercrop} * f_s * \%covered)$
- 36 f_l combinations

Vine Stage	density of cover crop canopy	% of soil surface covered by cover crop	f_{vine}	Fraction intercepted by cover crop (calculation)	f_l
0	none	0	0.1	0	0.10
III	average (50%)	100%	0.65	0.05	0.70

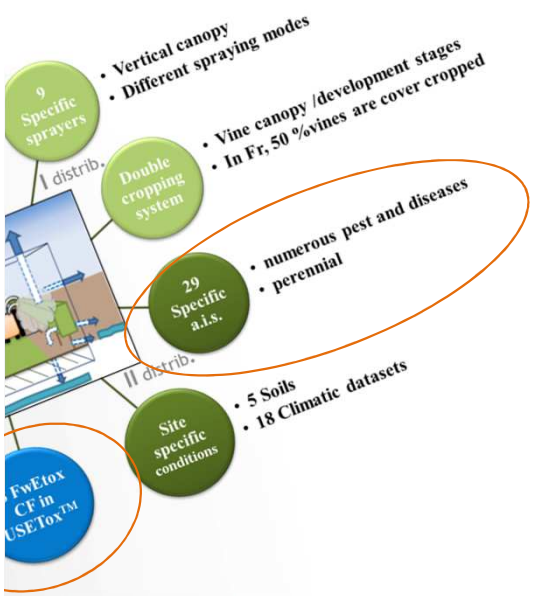
Picture Vincent Grall

Picture David Destoc

New p.a.i.s in PestLCI 2.0 and USETox™ characterization factors

PestLCI models organic p.a.i.s fate based on physical and chemical properties of the subtances

29 p.a.i.s were added in PestLCI 2.0



Molecular weight (g/mol)
Molar volume (g/mol)
Solubility in water (g/l)
Ref. Temp solubility (0C)
Vapour pressure (Pa)
Ref. Temp vapour pressure
pKa
Log Kow
Koc (l/kg)
Soil t½ (days)
Reference temp for pesticide biodegradation (oC)
Atmospheric OH rate (days) (cm3/molecules*sec)
Atmospheric OH rate ref temp (0C)
No sprayzone width (m)

Usetox™, best application practice to characterize toxic impacts of chemicals in LCA (Haushild et al. 2008), covers ~ 2500 chemicals for Fresh water ecotoxicity (FwEtox)

18 p.a.i.s CF were calculated for FwEtox

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Case study

2 real cases from regional typology of diversity of vineyard technical management: conventional , with different intensities of intervention,

Chenin Blanc, year 2011, different soils.

Functional Unit : 1ha

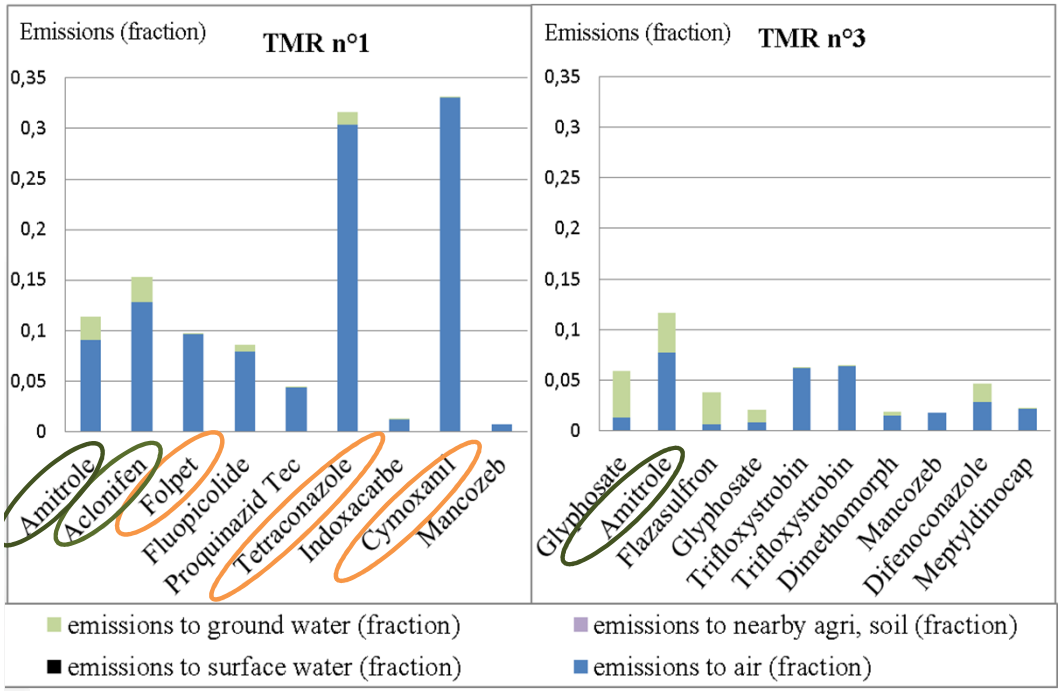
TMR 1
12.6 kg p.a.i.s
14 applications

TMR 3
4.17 kg p.a.i.s
11 applications

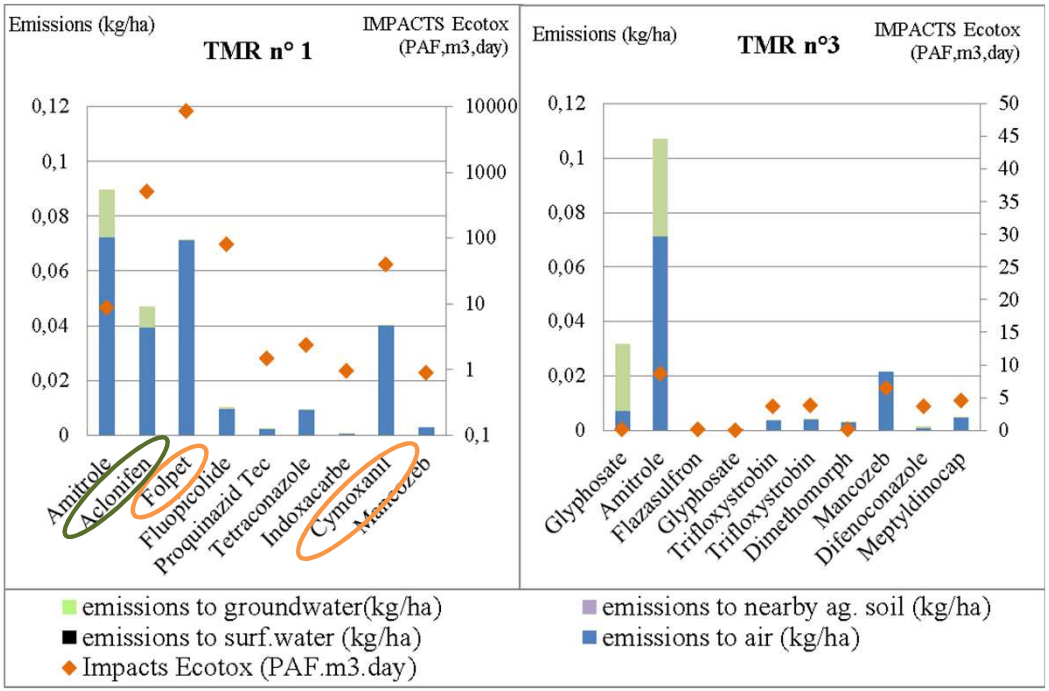
pesticide ai.s	Application rate	Crop type + development stage	Month of application	Application method	width treated
Aminotriazole	0,79	Grass I - all phases	april	sheltered boom	1,85
Aclonifen	0,31	Grass I - all phases	april	sheltered boom	1,85
Sulfur	5,89	*Vines II - h80% grass	may	tunnel sprayer	1,85
Folpel	0,74	*Vines II - h80% grass	may	tunnel sprayer	1,85
Fosétyl-Aluminium	1,47	*Vines II - h80% grass	may	tunnel sprayer	1,85
Fluopicolide	0,12	*Vines II - h80% grass	may	airblast sprayer	7,4
Fosétyl-Aluminium	1,75	*Vines II - h80% grass	may	airblast sprayer	7,4
Proquinazid Technique	0,05	*Vines II - h80% grass	may	airblast sprayer	7,4
Tétraconazole	0,03	*Vines III - a80% grass	june	airblast sprayer	7,4
Indoxacarbe	0,04	*Vines III - a80% grass	june	airblast sprayer	7,4
copper oxychloride	0,73	*Vines III - a80% grass	july	airblast sprayer	7,4
copper sulfate	0,18	*Vines III - a80% grass	july	airblast sprayer	7,4
cymoxanil	0,12	*Vines III - a80% grass	july	airblast sprayer	7,4
Mancozèbe	0,40	*Vines III - a80% grass	july	airblast sprayer	7,4
Glyphosate	0,54	Grass I - all phases	march	sheltered boom	1,95
Amitrole	0,92	Grass I - all phases	march	sheltered boom	1,95
ammonium thiocyanate	0,86	Grass I - all phases	march	sheltered boom	1,95
Flazasulfuron	0,02	Grass I - all phases	march	sheltered boom	1,95
Glyphosate	0,09	Grass I - all phases	may	sheltered boom	1,95
Trifloxystrobine	0,06	*Vines II - a50% grass	may	pneumatic sprayer side by side	7,8
Trifloxystrobine	0,06	*Vines III - a50% grass	june	pneumatic sprayer side by side	7,8
Diméthomorph	0,18	*Vines III - a50% grass	june	pneumatic sprayer side by side	7,8
Mancozèbe	1,20	*Vines III - a50% grass	june	pneumatic sprayer side by side	7,8
Difénoconazole	0,03	*Vines III - a50% grass	july	pneumatic sprayer side by side	7,8
Meptyldinocap	0,21	*Vines III - a50% grass	july	pneumatic sprayer side by side	7,8

Results and discussion

Emissions fractions



Emissions quantities and FwEtox impacts



- results consistent with literature (Vazquez-Rowe etal. 2012)
- Need of sensitivity analysis on various parameters

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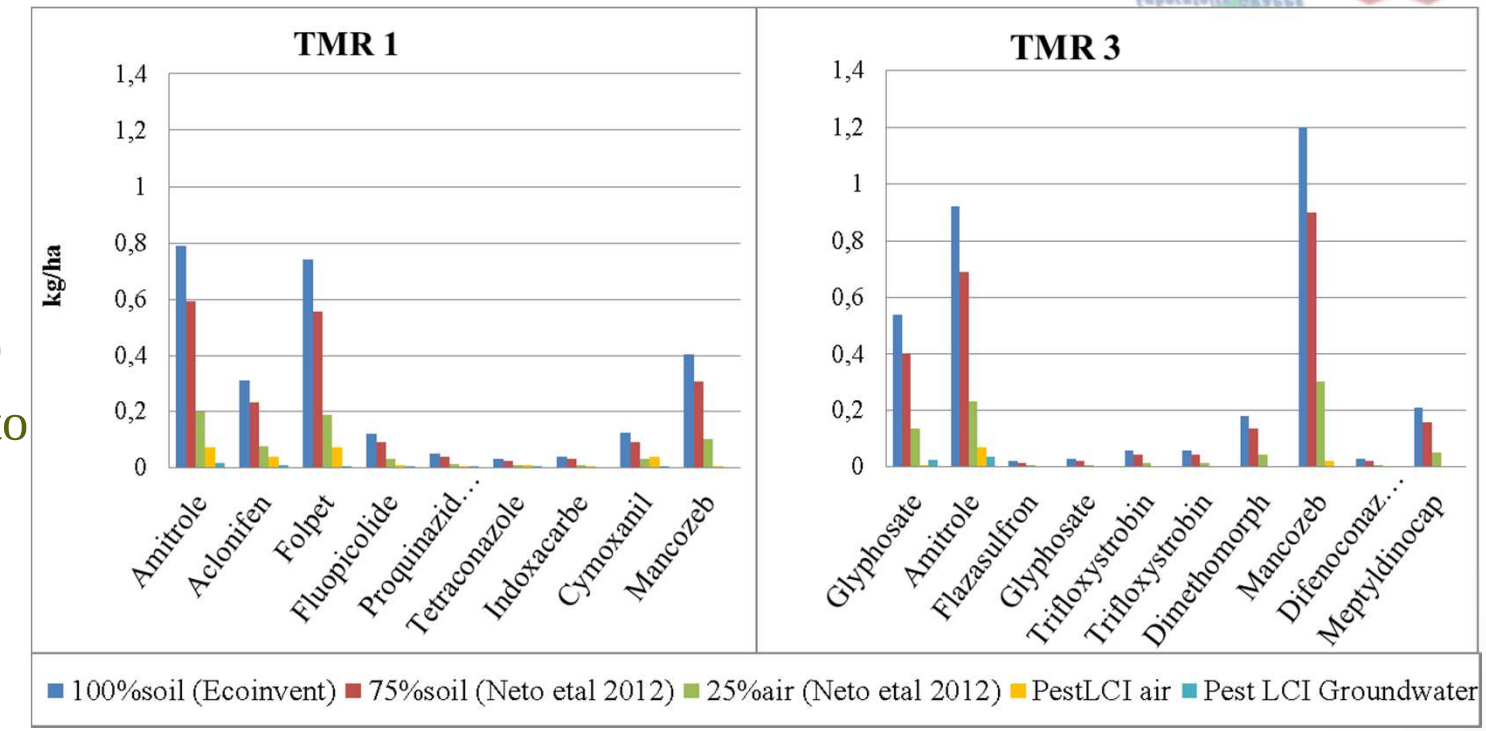
Results and discussion

Comparison with static approaches:

- 100% in agric. soil (Nemecek *et al.*, 2012)
- 75% soil, 25% air (Neto *et al.*, 2012)



Impacts	average impact
Impacts FwEcotox PestLCI 2.0 (PAF·m3·day)	484
impacts FwEcotox Ecoinvent (PAF·m3·day)	15 200
impacts FwEcotox Neto et al. (PAF·m3·day)	12 600

Discussion -perspectives

- PestLCI 2.0 was adapted without compromising the model framework
- Inorganic p.a.i.s are not covered by PestLCI 2.0 > need for a specific model to permit organic farming assessment
- Not included, consider for further improvement:
  - Airborne drift
  - p.a.i.s metabolites

  → difficult to model and/or lack of existing references
  - Spraying conditions
  - application parameters

  → More complicated inventory
  - % stones in the soil

Conclusion

- ✓ **Accounts for main viticulture specificities**
- ✓ Provides **emission and characterization factors** for main vineyards specific p.a.i.s
- ✓ Application to cases showed **high variations between p.a.i.s applications** due to p.a.i.s properties and application conditions
- ✓ Comparison to **static approaches** points out **huge differences of p.a.i.s emitted quantities and FwEtox** due to different system boundaries and phenomenon and a.i. properties accounting
- ✓ Can be used by **other vertical canopy crops**

Aknowledgements

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Thank you for your attention

Questions, discussion